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EQUIPMENT FOR THE RADAR INVESTIGATIONS
OF METEORS IN DUSHANBE

R. P. Chevotarev, et al

Foreign Technology Division
Wright-Patterson Air Force Base, Ohio

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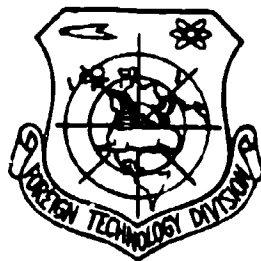
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by

R. P. Chevotarev, V. N. Sidorin, et al.



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IN DUSHANBE

By: R. P. Chevotarev, V. N. Sidorin, et al.

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All figures, graphs, tables, equations, etc.
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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	<i>А а</i>	A, a	Р р	<i>Р р</i>	R, r
Б б	<i>Б б</i>	B, b	С с	<i>С с</i>	S, s
В в	<i>В в</i>	V, v	Т т	<i>Т т</i>	T, t
Г г	<i>Г г</i>	G, g	У у	<i>У у</i>	U, u
Д д	<i>Д д</i>	D, d	Ф ф	<i>Ф ф</i>	F, f
Е е	<i>Е е</i>	Ye, ye; E, e*	Х х	<i>Х х</i>	Kh, kh
Ж ж	<i>Ж ж</i>	Zh, zh	Ц ц	<i>Ц ц</i>	Ts, ts
З з	<i>З з</i>	Z, z	Ч ч	<i>Ч ч</i>	Ch, ch
И и	<i>И и</i>	I, i	Ш ш	<i>Ш ш</i>	Sh, sh
Й й	<i>Й й</i>	Y, y	Щ щ	<i>Щ щ</i>	Shch, shch
К к	<i>К к</i>	K, k	Ъ ъ	<i>Ъ ъ</i>	"
Л л	<i>Л л</i>	L, l	Ы ы	<i>Ы ы</i>	Y, y
М м	<i>М м</i>	M, m	Ь ь	<i>Ь ь</i>	'
Н н	<i>Н н</i>	N, n	Э э	<i>Э э</i>	E, e
О о	<i>О о</i>	O, o	Ю ю	<i>Ю ю</i>	Yu, yu
П п	<i>П п</i>	P, p	Я я	<i>Я я</i>	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere.
 When written as ѣ in Russian, transliterate as yѣ or ѣ.
 The use of diacritical marks is preferred, but such marks
 may be omitted when expediency dictates.

EQUIPMENT FOR THE RADAR INVESTIGATIONS OF METEORS IN DUSHANBE

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Kolmakov

This article describes the equipment built at the Astrophysics Institute of the Tadzhik branch of the USSR Academy of Sciences for the measurement of upper atmospheric winds according to the IQSY program, for determining the coordinates, altitudes, radiants, and velocities of meteors, and for studying the physics of meteors and the upper atmosphere. Brief data concerning the equipment's operation is presented.

The first radar observations of meteors were made in the 1940's using ordinary radar meteor band detection devices. Only a photoregistration system, but occasionally noise suppressors, was added, and the antenna systems were modified. On the basis of these first generation meteor radar devices the daily and seasonal flux in meteor activity was determined, meteor velocities were measured, daytime currents were discovered, and the relationships between volume, count, and parameters were defined [1].

Subsequently, second generation specialized meteor radar devices were built. Although some of their parameters were far from optimum, they were designed for the purpose of solving meteor

related problems and for shedding some light on such topics as meteor orbits, trail drifts and so forth. Similar radar devices were constructed both abroad and in the Soviet Union - in Kharkov, Kazan, Tomsk, and other places.

The equipment designed and built in the radar laboratories of the Astrophysics Institute (Tadzhik branch) of the USSR Academy of Sciences between 1964-1966 can be viewed as being second generation radar detection devices.

While the equipment was being developed, the job to be accomplished included measuring high winds in the M-zone by the coherence-impulse method [2], producing high resolution wind charts, measuring the radiants and velocities of individual meteors both by a method developed earlier [3] as well as using that method initiated by one of the authors [4].

The possibility of conducting various experiments for the purpose of studying the physical processes was discussed as were the prospects of researching complex photo radar observation techniques.

Figure 1 illustrates the functional chart of the equipment being discussed. The parameters are given below:

1. Primary equipment.

Carrier frequency - 37.4 MHz; transmitter peak power - 80 kW; repetition frequency - 500 impulses per second; squared pulse duration - 6.5 μ s; passband of primary and outlying receivers - 600 kHz; threshold pick-up of receivers - $8 \cdot 10^{-14}$ V; goniometer receiver passband - 350 MHz; threshold pick-up - $5 \cdot 10^{-14}$ W; signal relay circuit passband - 6 ms; photoregistration - frame by frame.



Fig. 1. Functional chart. 1 - synchrounit; 2 - 37.4 MHz transmitter; 3 - 37.4 MHz receiver; 4 - noise filter unit; 5 - precision ranging circuit; 6, 7 - relayed signals receivers; 8, 10 - remote point receivers; 9, 11 - relay transmitters; 12 - phase block; 13 - goniometer; 14 - meteor simulator; 15 - 73 MHz transmitter; 16 - 73 MHz receiver; 17 - antenna commutator; 18 - multi-beam frame by frame photography indicator; 19 - continuous recording indicator; A₁-A₁₈ - antenna.

2. Auxiliary equipment.

Carrier frequency - 73 MHz; transmitter peak power - 50-60 kW; pulse duration - 10 μ s; repetition frequency - 100 impulses/s (synchronized with a fundamental frequency of 500 Hz), passband - 150 KHz; threshold pick-up - $6 \cdot 10^{-14}$ V; noise suppressor - from the primary equipment, continuous registration for the duration of the signal on a frequency of 37.4 MHz.

The radar equipment works in the following manner: the synchrounit produces 2 km and 20 km quartz stabilized range marks, and provides a preset repetition frequency. Impulses from the synchrounit trigger the 37.4 MHz transmitter, the phase goniometer commutator, multibeam indicator range scans, and the precise range circuits. They also trigger the 73 MHz transmitter, sustain the synchronous revolution of the noise suppression circuit magnetic drum and, when necessary, modulate the meteor phase goniometer simulator generator.

The primary transmitter's preset generator is quartz stabilized on a frequency of 6.233 MHz. The carrier frequency is determined by multiplying the quartz' fundamental frequency. In addition to the carrier frequency of the emission impulse, the generator transfers the fundamental frequency to the phase unit, phase goniometer and meteor simulator. The phase unit, in principle, operates in the same way [2] and has been used to obtain high wind readings according to the IQSY program. The phase unit receives intermediate frequency signals from the primary receiver; it emits two 90° in-phase Doppler frequency voltages which reach the multi-beam indicator. The phase goniometer, using five special antenna, measures the precise coordinates of the reflecting centers of meteor trails as well as the drift velocity [5]. The two goniometer output voltages also reach the multibeam indicator.

To calibrate the phase goniometer, a special unit for meteor simulation is used, one which is equipped with special antenna set off to the side of the system's primary antenna structure. Both videosignals from the central receiver and outlying points (the latter occurring after relay) and synchronunit impulses reach the noise filter circuit. Photoregistration devices 6 and 7 are triggered by the appearance of the signal on any of the points.

Both videosignals coming along the trichannel and the impulses from the synchronunit and noise filter circuit reach the precision ranging circuit. The six output voltages of the precision ranging circuit reach the multibeam indicator [8].

The multibeam indicator is capable of frame by frame photography which makes possible instantaneous registration of a signal entering from the 12 channels within 0.1-0.5 s. Its operation is discussed in detail in work [7].

The receivers of each of the two outlying points record the reflection of meteor trails. These signal modulate the transmitter emission which relay the gathered information to a central point

on frequencies around 100 MHz. The central point itself has two receivers for relaying signals. Together with the central point, the outlying points measure the radiants and individual velocities of each meteor [3] while, in conjunction with the precision ranging system, define the reflecting point coordinates, radiants, and velocities of the individual meteors [4].

In this manner the system of outlying points, phase goniometer and phase unit produces an independent stand-by duplicate system of measurements for such parameters as coordinate centers, meteor velocities, radiants, and drift trails, all of which increases their reliability and accuracy.

The 73 MHz impulses of the transmitter operating in the self-generating mode become synchronized with the impulses of the transmitter on 37.4 MHz. Receiving and transmitting usually is carried out on a single antenna via the antenna commutator. The receiver, operating on 73 MHz, emits a signal to the continuous recording indicator. Signals from the primary receiver, range scans from the multibeam indicator and intensification impulses from the noise filter circuit reach this indicator [6].

Besides registering signals on two frequencies, the indicator makes possible measurement of any reflected signal's duration with an accuracy of 4-20 ms. The auxiliary equipment is used primarily for studying the physics taking place.

The equipment ensemble consists of 18 antennas. Transmission and receiving antennas A_1 and A_3 are five-element wave channels which will be used for wind measurements during the IQSY. A_2 and A_4 are halfwave dipoles located $\lambda/3$ from the Earth's surface. They have the dual function of making photo-radar and natural observations of meteor activity. A_{11} thru A_{15} are similar in design to A_2 and A_4 and are part of the phase goniometer system. A_{17} is a seven-element "wave channel" variety antenna which operates on a frequency of 73 MHz. A halfwave dipole (A_{19}) can be inserted in

its place. A_5 and A_6 are the five-element antennas of the signal relay circuit receivers located at a height of 10 m. A_8 and A_{10} are similar to them but belong to the relay transmitters and are at a height of 7 m. A_7 and A_9 are halfwave dipoles belonging to the meteor simulator unit. All these antenna, except for A_5 , A_6 , A_8 and A_{10} can achieve azimuth rotation.

The outlying points are temporarily situated 2 and 2.4 km from the central point. The angle between the paths to the outlying points is about 50° . The distance to the outlying points is measured with an accuracy of ± 3 m.

This set of equipment was gradually placed into operation beginning in September 1964 and became fully operational in January 1967.

Presently, the ensemble can measure the following parameters: absolute range to the meteor trail with an error of not more than 0.1 km; range variations with an error factor of not more than 0.05 km; the duration of any quantity to within 4 ms; the altitude of reflecting signals; velocity of meteor trail drift from 0 to 200 m/s; meteor radiants to within an accuracy of $\pm 5^\circ$ and angle coordinates with an accuracy of $\pm 2^\circ$ at the outlying points; angular coordinates with an accuracy of $\pm 0.3^\circ$ using the phase goniometer, as well as several other parameters.

Using a phase goniometer just like outlying points, will make possible still greater accuracy when measuring angular coordinates and radiants.

In three years of operation the ensemble registered in excess of 500 thousand meteors. Data was obtained for high level winds over Tadzhikistan, high resolution wind charts, radiants and meteor velocities. The joint photoradar observations displayed a high degree of accuracy for measuring coordinates and produced some data concerning the physics of meteors.

Specific results regarding the astronomy and physics of meteors obtained during the ensemble's operation have been published [9, 10, 11, 12] and will be published in the future.

The radar laboratory team gained much practical experience during the equipment construction and operation phases, such that the assembly of a much improved version of the radar can be expected - one having optimum parameters, that is, a third generation radar device.

In conclusion the authors express their appreciation to the director of the Astrophysics Institute, P. B. Baĭadzhav, for his help in conducting these qualitative radar observations of meteors in Dushanbe.

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